SOLAR TRES PROJECT & COMPONENT R&D

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POWER TOWER EVOLUTION

- Solar One (SI) - Demonstrated Central Receiver technical feasibility
- Solar Two (SII) - Demonstrated Molten Salt Receiver Technology and Dispatchability with 3 hours of Thermal Storage
- Solar Tres (SIII) - First COMMERCIAL project
- Solar MWe 50 & 100 - Commercially competitive projects in economies of scale

SETTING THE RECORD STRAIGHT ON SOLAR TWO

"Principle goal of Solar Two is to significantly reduce the perceived technical and economic risk associated with building the first commercial central receiver power plants"

Solar Two:

- Successfully Demonstrated New Technology:
  - Molten Salt Receiver Technology
  - Dispatchable Thermal Storage
- Revealed many Technology Implementation Issues
- Validated Solutions for these Issues
- Led to Cost Reductions and Better Solutions
- Gave Private Industry the Confidence to Build a Commercial Plant

WHERE WE ARE TODAY

- **Private Industry is taking risk** in a public/private partnership (SIII)
- There is a market in several countries
- The technology is sufficiently mature to export
- Solar Tres incorporates many significant innovations

Without Collaboration from DOE, SANDIA and NREL,
We would not have a commercial project today

SOLAR TRES

OWNERSHIP & FINANCING

- SIII Jointly Owned by Nexant Inc. and Ghersa and will Operate as an IPP
- SIII is being Financed by:
  - EU and Spanish Government Grants
  - Private Industry Investors
    - **Negotiations underway with Sener, Boeing & Nagle Pumps**
  - Bank Financing
- FINANCIAL CLOSURE Forecast Late 2nd Qtr 2002

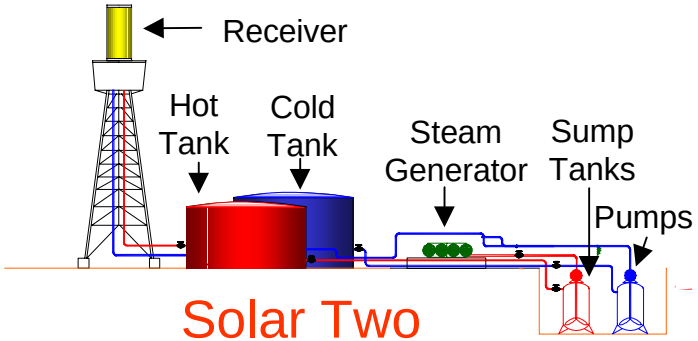
EU and SPANISH GOVERNMENT SUPPORT

- GRANT STATUS
  - BRUSSELS $4.6 M TECHNOLOGY GRANT AWARDED
  - BRUSSELS ADDITIONAL $4.6 M GRANT PENDING
  - SPANISH TO DESIGNATE SIII AS STRATEGIC PROJECT
    - Interest Free Loans $ 25 M
    - Technology Grant - Receiver Manufacturing $ 8 M
  - POWER PURCHASE PREMIUM Pending
    - $ 0.137- 0.165 / kWh (25 - 30 Pst/kWh) plus Market $ 0.044/kWh (8 Pst / kWh)
    - **A $ 0.165 / kWh Premium is Equivalent to $ 154 M Discounted over 30 yrs**
  - FREE PROVINCIAL LAND for Manufacturing Facilities

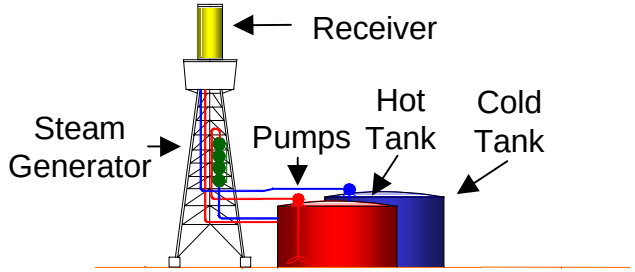
EUROPE IS INVESTING HEAVILY IN SOLAR TRES

SIII DESIGN AND TECHNOLOGICAL INNOVATIONS (Continued)

System Simplification



Solar Two



Solar Tres

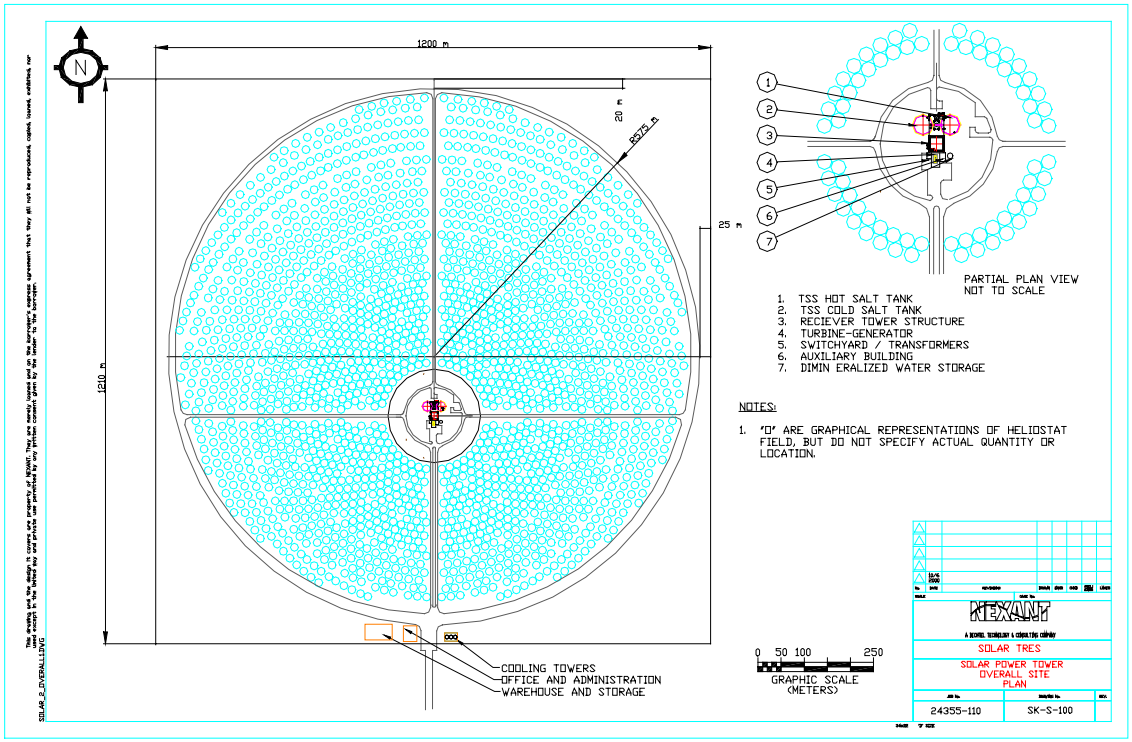
- Simplification of Plant Molten Salt Systems
  - Optimized Plant Physical Arrangement
  - 50% reduction in the number of valves/control valves
  - Long shafted vertical turbine pump qualified by **Sandia**
  - Elimination of sump vessels
  - Magnetic valves eliminating seals being qualified by **Sandia**
  - Energy absorbing downcomer eliminating Receiver Outlet Vessel and major drag valve under test by **Sandia**

SIII DESIGN AND TECHNOLOGICAL INNOVATIONS

- Receiver Tube Metallurgy
  - Nickel Alloy / Receiver Panel qualified by **Sandia**
  - 3% Improvement thermal efficiency with
    - internal headers
    - improved oven box design
  - Greater Allowable Max. Incident Solar Flux on Receiver
    - S II 850 kW/m^2
    - S III 1.5 MW/m^2
- Heliostat Design
  - Simplified design applying commercial components e.g., low cost drives
  - Non volatile heliostat memories
  - 45% reduction in cost

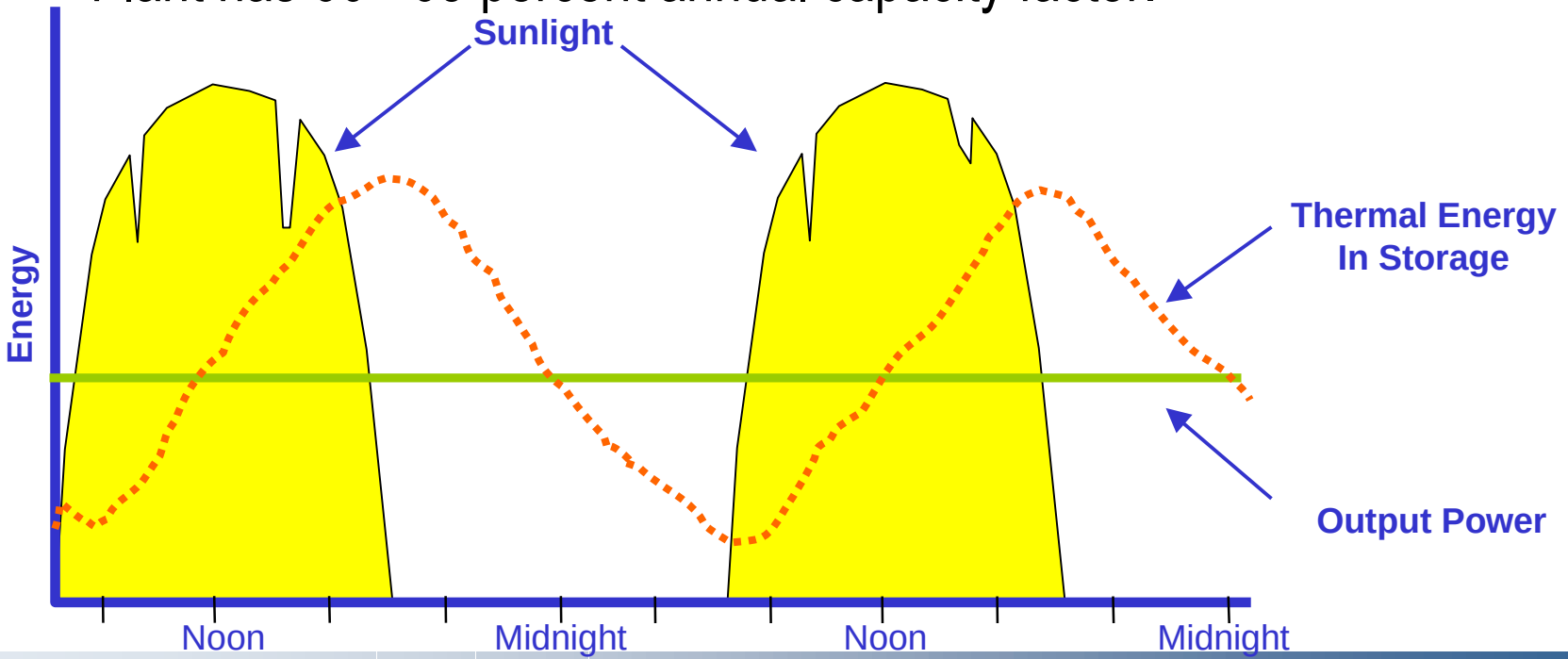
SIII DESIGN AND TECHNOLOGICAL INNOVATIONS (Continued)

- Stacked Steam Generator allowing passive draining of Molten Salt
- Reheat steam turbine improves efficiency by 6%
- Molten Salt Instrumentation
  - New State-of-the-Art Commercial Pressure, Level & Flow sensors being qualified by **Sandia**



THERMAL STORAGE & DISPATACHABLE POWER

- Power generation decoupled from energy collection with Thermal Storage
- Figure illustrates central receiver w/ 16 hours of storage operates around the clock
- Plant has 60 - 65 percent annual capacity factor.



SIII DESIGN STATUS

- Design Criteria Established
  - Incorporated SII “LESSONS LEARNED” and Sandia Technology Development
- Conceptual Design Completed
- Site Selection Underway
- Suppliers for All Critical Equipment Identified supported by Preliminary Technical Data & Drawings
- Capital & O&M Cost Estimates Developed

Sandia RESEARCH & TECHNOLOGY DEVELOPMENT COMPONENT R&D

- Over the last 4 years **Sandia** has provided ~$3M of support to the program
- Active Sandia Support to the SIII Project Requested
- Continued SIII FY 02 Technical Support to Industry
  - Close Consultation with Industry
  - Research & Technical Development Tasks Prioritized
- SIII TEST & EVALUATION OVERSIGHT
- R&D FOR 50 MW & 100 MW SCALE UP

SOLAR TRES

WHY COMPONENT R&D?

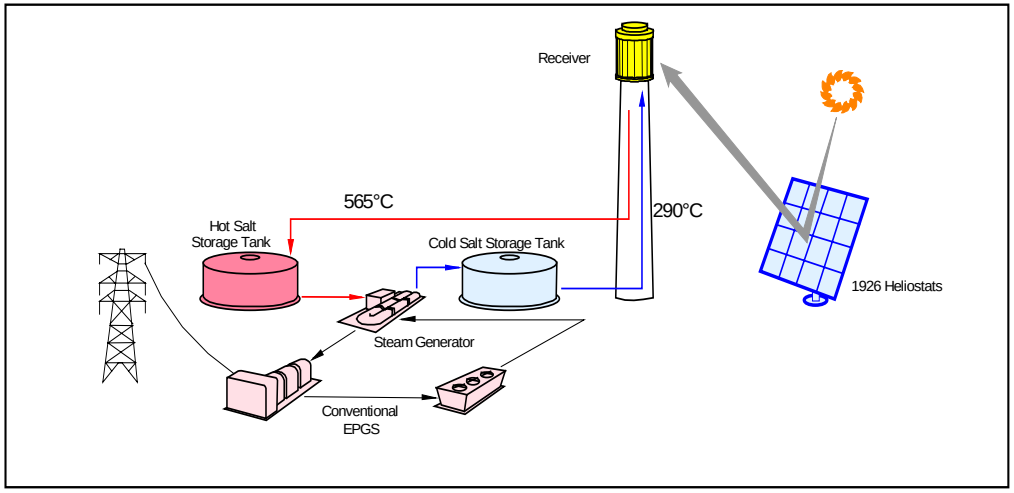
- Must keep DOE and the Labs as Active Participants to:
  - Facilitate & Support Export Potential for American Hardware & Create US Jobs
  - Stay Involved and Leading the Technology
  - Prevent TECHNOLOGY FLIGHT
    - CIEMAT, European Sandia Equivalent, is a Participant and more than willing to fill the void if DOE reduces support
    - E.g., Loss of WIND TURBINE Technology to Europe
    - Prevents the loss of the $800 M Sunk Cost to date
- Low Cost Leveraged DOE Investment with Substantial Payback

INTERMEDIATE & LONG TERM R&D FOR 50 MW & 100 MW SCALE-UP

- INDUSTRY SUPPORTED R&D (NEXANT, NAGLE & BOEING)
  - 50 MWe and 100 MWe System Scale-up
  - Long-Shafted Pump Qualification for 50 MWe and 100 MWe
  - Advanced Receiver Component & Materials Qualification
  - Lessons Learned from Solar Tres Operations and scale-up issues
  - Continued Heliostat Component and Hardware Development & Qualification

PEER REVIEW BACKUP MATERIAL

SIMPLIFIED POWER TOWER SCHEMATIC



- Major Hardware System Elements
  - RECEIVER (RS)
  - THERMAL STORAGE (TSS)
  - COLLECTOR FIELD (CF)
  - STEAM GENERATOR (SGS)
  - TURBINE - GENERATOR (EPGS)

15 MWe SIII PLANT PARAMETERS

Collector Field (CF)- Heliostats

- Surround field
- 240,000m^2 of mirrored surface
- 2,493 heliostats (96.3m^2) of silvered low-iron glass
- Individually micro-computer controlled heliostats, that track the sun and focus the solar energy on the receiver

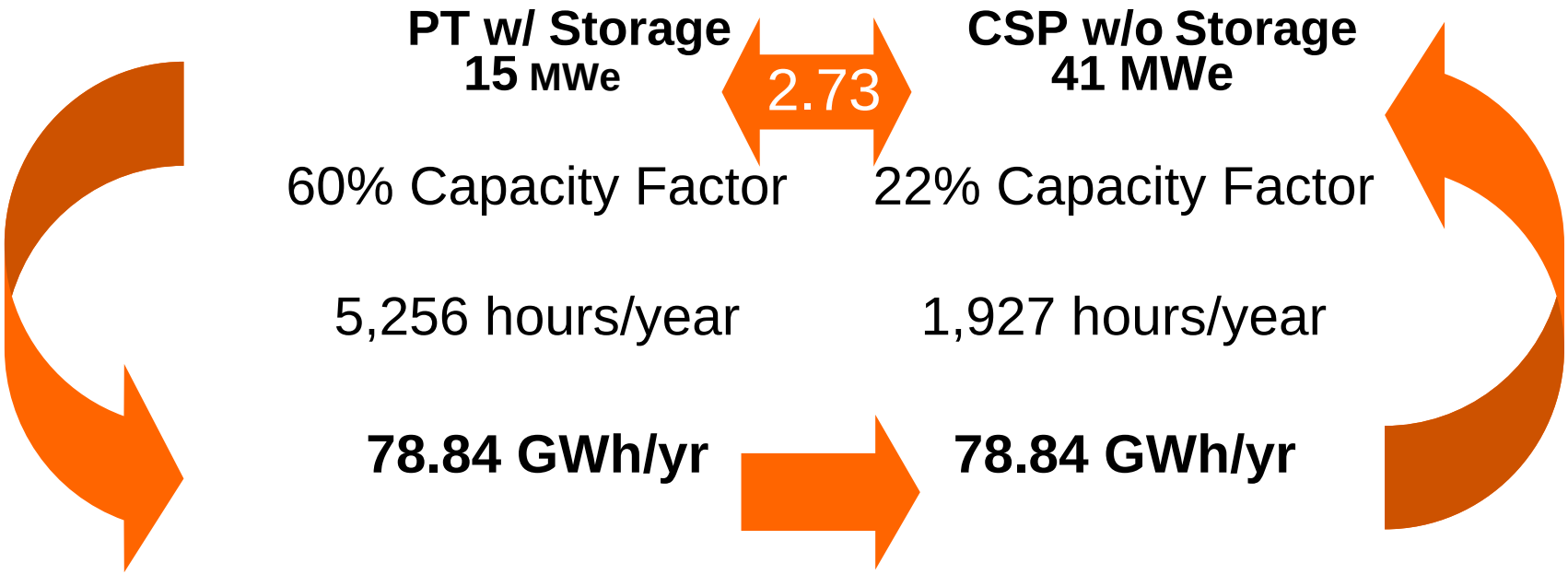
Receiver System (RS)

- Solar Heat Exchanger where nitrate salt goes from 290^{o}C to 565^{o}C
- 120 MWt receiver (8 m diameter, 10m high, Inconel Alloy tubes) on top of 100 m high structural steel tower
- Max. design flux 1 MW/m^2
- Receiver efficiency 89%

Thermal Storage System (TSS)

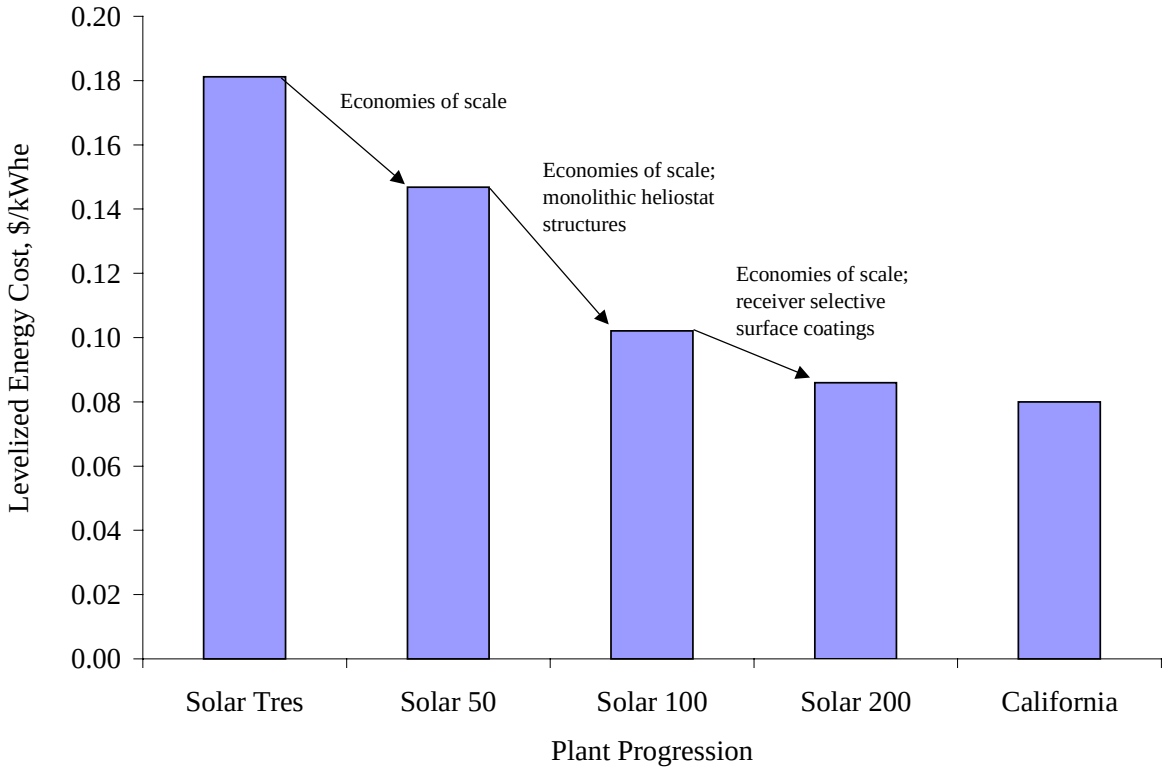
- Two insulated tanks (hot and cold), storing 6,250 MT of molten nitrate salt, with pumps to circulate the salt to the RS and SGS
- Hot/Cold tanks: 3,150/3,200 m^3, 21/21.5 m diameter, 13 m high.
- TSS capacity 16 hours of storage

MULTIPLYING EFFECT OF THERMAL STORAGE



Plant w/o storage in order to produce the same total output would have to be 2.73 times larger which drives plant capital cost up

SCALE UP


0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Levelized Energy Cost, $/kWhe
Economies of scale
Economies of scale; monolithic heliostat structures
Economies of scale; receiver selective surface coatings
Solar Tres
Solar 50
Solar 100
Solar 200
California
Plant Progression

GREEN HOUSE GAS - Emissions

- SPT technology contributes to a reduction in near term of GHG emissions.
- SIII 78, 000 MWhe annual output compared to conventional fossil fuel power plants & Trough Technology of same output:

78.000 MWe Annual Output	SPT-SOLAR TRES	Coal Fired Plant	Fuel Oil Fired Plant	Methane (Natural Gas) Fired Plant	Trough Plant w/ Natural Gas
CO_2 – Metric Tons	0	87,000	59,000	47,000	17,000
SO_x MT	0	1,400	190	0	0
NO_x MT	0	45	25	23	8
Capital Cost of Energy in /kWh	2,199 / kWe* 0.21 / kWhe	1,200 / kWe 0.040 / kWhe	1,000 / kWe 0.061 / kWhe	1,000 / kWe 0.043 / kWhe	3,000 / kWe 0.18 / kWhe

* Comparing the SOLAR TRES Capacity Factor (CF), 60% due to energy storage, with Trough Technology with a CF ~22%, the ratio resultant is 2.73. When updating the capital cost with this ratio (2.73), the investment for each SOLAR TRES kWe installed results 2,057 .

CONTINUED FY 02 & NEAR TERM RESEARCH & TECHNICAL DEVELOPMENT ACTIVITIES

- Valve & Valve Packing Component Qualification
- Salt System Metallurgy & Materials Qualification
- Heliostat Component & Materials Testing
- Heliostat Design Review and Oversight
- State-of-the-Art Molten Nitrate Salt Instrumentation
- Energy Absorbing Downcomer Final Qualification
- TEST & EVALUATION (T&E) Planning with Direct Participation in SIII

PEER REVIEW BACKUP DATA

WORD DOCUMENT HAND OUT